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<p>(54) Title: PHARMACEUTICAL TABLET PRESS CONTROL MECHANISM</p>		
<p>(57) Abstract</p> <p>Control and monitoring instrumentation for a high speed double rotary tablet press mechanism. Each tablet press side has strain gauges producing signals indicative of tablet compression. The strain gauge generates control signals received by a peak detector, which holds the maximum strain signal. The peak signals are converted to digital and provided to a microprocessor that first controls operation of the reject gate and regulates tablet consistency by controlling powder fill into the dies, and second, passes information to RAM. The RAM is shared by a master CPU, clocked 180° out of phase with the microprocessor. The master CPU produces either a CRT or printed output of both raw and statistically abstracted tablet press data.</p>		

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PHARMACEUTICAL TABLET PRESS CONTROL MECHANISM

BACKGROUND OF THE INVENTION

This invention relates to pharmaceutical tablet press mechanisms, and more particularly, relates to a control and monitoring system for operation of a high speed rotary tablet press.

5 Rotary tablet press mechanisms designed to compress and form medicinal or related powders or granules into tablets have long been known in the pharmaceutical art. An example of prior art tablet presses is disclosed in U.S. Patent
10 No. 3,255,176 issued June 14, 1966. In such rotary presses, powders or other materials that can be formed into tablets are placed in one of a plurality of generally cylindrical dies mounted within a rotary die holding turret. A pair of
15 opposed cam operated punches compress the powder from both ends of each tablet forming die and thereby compact the powder into an individual tablet. The rotary turret arrangements allows a plurality of punch and die sets to continuously
20 produce tablets around the circular path followed by the rotary press by sequentially contacting an arrangement of cams above and below the turret that lift and lower the punches. In modern tablet press machines, pharmaceutical tablets are produced at
25 rates as high as 12,000 tablets per minute.

It is highly desirable that all tablets prepared by rotary tablet press mechanisms be of uniform and precisely controlled size and weight. This is especially true for medicinal tablets, as
30 carefully prescribed dosage amounts are difficult to achieve without accurate tablet size and weight control. Inaccuracies in tablet size and weight stem from a variety of different circumstances, but

most commonly result from uneven introduction of the powders into the die and punch combinations. Inaccuracies can also result from imperfections or wear in the tablet press or die elements, or from changes in the density or moisture content of the compressed powder.

Several prior art mechanisms have been employed to evaluate the weight of compressed tablets and determine if such tablets are defective. Generally, individual tablets are monitored by evaluating the compression between the punches during tablet formation. Overweight tablets, resulting from excessive powder or granular material placed between the opposing punches, will cause higher than normal compacting forces. Likewise, underweight tablets, resulting from a smaller than normal quantity of powder or granular material between the opposing punches, will result in less than normal compressive forces between the opposing punches. Thus over and underweight tablets are typically detected in table presses through use of a strain gauge (or related mechanism) for measuring the forces in the opposing punches. Such a strain gauge is disclosed in U.S. Patent No. 3,791,205 issued on February 12, 1974. U.S. Patent 3,734,663, issued May 22, 1973, discloses a control circuitry that monitors, and if necessary, changes the amount of powder placed in the die in response to measured tablet compressive forces, as detected by changes in resistance in a strain gauge.

Tablet press mechanisms also typically include a structure for removing the formed tablet from the punches and dies. Normally, rotary tablet press mechanisms include a second cam system that causes

the lower punches to lift the formed tablet, after compression, to the surface of the rotating turret. A blade or the like is then disposed slightly above the rotary disc at a location intersecting the path of the dies and hence the tablets that have been lifted from the dies. Contact of the tablet with the blade then scrapes the tablets from the turret to a discharge shoot.

Often, blade mechanisms of the kind described above are combined with a reject gate, such as is disclosed in U.S. Patent Application Serial No. 650,346 filed September 13, 1984, and owned by the same entity as the present application. Defective tablets are detected through analysis of the punch forces as established by the strain gauge, and a pneumatic air jet is timed to deflect defective tablets away from the blade into a reject chute. Proper operation of such a mechanism requires instrumentation for precise control of the pneumatic air jet in response to a signal indicating a defective tablet. Such instrumentation in turn requires highly precise devices to produce the signal indicating the specific defective tablet to be rejected. For very high speed mechanisms, such as those producing as much as 12,000 tablets per minute, even minor imprecisions can result in rejection of other than the specific defective tablet. To avoid such failures, tablet press control mechanisms are usually set to reject plurality of tablets in the vicinity of the detected defective tablet.

Additionally, unnecessary tablet rejection can be minimized if precise information regarding individual punch compression activity can be evaluated by an operator with a number of indicia

displayed. Thus, when an operator is able to monitor compression forces precisely during the operation of the rotary press, and receives such further information as the range of compressing force produced by each punch set and statistical comparisons of the forces produced over time during press operation, mechanical and component wear problems can be identified while still incipient, and can thereafter be corrected before the problem is exacerbated. Likewise, individual mechanical variations between punches or cams can be detected, and adjustments made to compensate for differing die and punch wear or differing adjustment of other individual press components.

Many rotary press tablet machines that require monitoring are double acting presses, that is, the machine possesses a set of compressive cams on opposite sides of the turret that act simultaneously to produce tablets. For such double rotary tablet presses, a dual system of compression detectors, monitors, reject gates, and control systems is highly advantageous. Such dual monitoring allows comparison of the operation of each side of the tablet press during operation, so that to the extent possible, the operator can maintain equal efficiency of each side.

Accordingly, it is an object of this invention to provide a pharmaceutical tablet press control mechanism suitable for use with a double rotary tablet press that precisely monitors both tablet compression information and defective tablet rejection information.

It is a further object of this invention to provide such a press that monitors compression force for each individual punch set.

5 It is an additional object of this invention to provide such a press control and monitoring mechanism that provides information to an operator regarding press compression concurrent with operation of the system.

Another object of this invention is to provide such a tablet press control and monitoring system that produces a statistical abstract of press compression information.

10 Yet another object of this invention is to provide such a tablet press control and monitoring system that produces detailed information regarding tablet press performance concurrent with press operation in a manner that is both visually
15 descriptive and relatively easy to use.

SUMMARY OF THE INVENTION

20 These and other objects of the invention are achieved by providing control and monitoring instrumentation for a high speed double rotary tablet press mechanism. Each side of the mechanism has three strain gauges producing signals indicative of tablet final compression, precompression and compression during tablet
25 release. The strain gauges generate control signals that are received by a peak detector, which holds the peak signal representing maximum strain. The peak signals are converted to digital information, which is then provided to a microprocessor.

30 The microprocessor performs two functions. It first controls operation of the reject gate and regulates tablet consistency by controlling powder fill into the dies. Second, it passes information

on to a Random Access Memory unit. The RAM is shared by a master CPU that is clocked 180 out of phase with the microprocessor. The master CPU processes the RAM information and produces either a
5 CRT or printed output of both raw and statistically abstracted tablet press data.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a pictorial perspective illustration of a pharmaceutical tablet press mechanism connected to a tablet press controller constructed
10 in accordance with this invention;

Fig. 2 is a side cross-sectional view of a portion of the tablet press mechanism illustrated in Fig. 1 showing the tablet press dies;

Fig. 3 is a top plan view of a portion of the tablet press mechanism illustrated in Figs. 1 and 2, showing separation of the formed tablets from the dies and the mechanism for rejection of defective tablets;

Fig. 4 is a schematic illustration of the operation of the pneumatic tablet rejection system;

Fig. 5 is a schematic diagram of the control system of the controller of Fig. 1;

Fig. 6 is a block diagram showing a master CPU and microprocessor of the control system of Fig. 5;

Fig. 7 is a graphical representation of the clock waveforms and timing waveform of the CPU and microprocessor of Fig. 6;

Fig. 8 is a block diagram of a peak detector circuit of the control system of Fig. 5;

Fig. 9 is a schematic diagram of the peak detector of Fig. 8;

Fig. 10 is a graphical representation of the waveforms associated with the peak detector of

Fig. 9;

Fig. 11 is a block diagram of a multiplexer and A-to-D converter circuit of the control system of Fig. 5;

5 Fig. 12 is a block diagram of a sensor/timing circuit of the control system of Fig. 5;

Fig. 13 is an illustration of a graphic display produceable by the controller of Fig. 1;

10 Fig. 14 is an illustration of a second graphic display produceable by the controller of Fig. 1; and

Fig. 15 is an illustration of a third graphic display produceable by the controller of Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

15 Referring now to Fig. 1, a tablet press mechanism 10 is illustrated along with a controller 12. The tablet press mechanism includes a rotary turret 14 holding a plurality of dies (not shown in Fig. 1) for the formation of tablets from powders
20 compressed between punches (also not shown in Fig. 1). The rotary turret 14 rotates at a high angular velocity between an upper and lower cam mechanism for operation of the tablet forming punches. Once formed, tablets are moved from the
25 vicinity of rotary turret 14 to an eject duct system 16 and to an exit duct 18. Defective tablets are ejected from the reject exit 20.

The preferred embodiment of the invention includes controller 12 having a CRT display 22 and
30 an alpha-numeric input 24. Controller 12 includes a printer 26 for printing fixed information as requested by the operator. For convenience, the entire controller 12 is contained within a unitary

cabinet 28 that is preferably movable on wheels.

Referring now to Fig. 2, a portion of the tablet punch and die mechanism is illustrated. A plurality of dies 30 are mounted within rotary press turret 14. Each die defines a cylindrical cavity 32 into which punches 34 may slide vertically for tablet formation. Medicinal powder 36 is inserted into cylindrical cavity 32 and compressed between the punches to form a tablet 38. The compressive action of punches 34 result from connection of the punch heads 40 with an upper cam 42 and a lower cam 44. Each punch 34 is operated by cams 42 and 44 and by rotation of rotary turret 14, since the cams are fixed with respect to the turret and the punches rotate with the turret.

Removal of the formed tablet 38 from the cylindrical cavity 32 is affected by operation of a lifting cam 46 contacting only the lower punches such that as the turret rotates, tablet 38 is lifted to the top surface 48 of the rotary turret 14.

Tablets 38 are then moved from the top surface 48 of the rotary turret 14 by a guide wall 50. Defective tablets are ejected from the vicinity of guide wall 50 by a pneumatic jet of air from a nozzle 54 of pneumatic tube 52.

Referring now to Fig. 3, tablets 38 rotate clockwise with rotating turret 14. As tablets 38 rise from cylindrical cavity 32, they contact guide wall 50 which guides the tablets from the vicinity of dies 30 along an ejection path 51. The tablets 38 are deflected downwardly by a downward slanting wall 56 to eject duct 16 and out exit duct 18 (Fig. 1). Rejected tablets are moved by a

5 pneumatic jet of air from nozzle 54 into a reject
area 58 and out reject exit 20 (Fig. 1). In the
preferred embodiment, the reject gate includes a
constant low pressure air flow of approximately 5
P.S.I. from a low pressure tube 60. The constant
air flow improves rejection of unusually shaped
tablets. Also in the preferred embodiment, the
reject gate includes a constant air flow from an
upper nozzle 62 to create a vacuum in the reject
10 area 58. Details of the operation of the preferred
embodiment of the reject gate are contained in
co-pending U.S. Patent Application Serial
No. 650,346, filed September 13, 1984, and owned by
the same entity as the present application.

15 Referring now to Fig. 4, control of the
pneumatic jet through the nozzle 54 is
illustrated. Generally, pressurized air from an
air pressure source (not shown) is fed through a
conduit 64 to a two-way pressure operated valve
20 66. Valve 66 gates the air from conduit 64 to
nozzle 54.

Pressurized air from the air source is also
provided to first and second air control solenoids
70 and 72 via a conduit 68. Each air control
25 solenoid 70, 72 is controlled by a reject gate
controller logic 501 (as described hereinafter).
When air control solenoid 70 is actuated by reject
gate controller logic 501, air from conduit 68 is
passed to the two-way pressure operated valve 66,
30 sliding valve 66 to the right, opening the path of
air pressure from conduit 64 and out through nozzle
54. Similarly, actuation of air control solenoid
72 slides the two-way operated pressure valve 66 to
the left, which closes the path of air flow from
35 conduit 64 to nozzle 54, thus cutting off the air

flow.

The tablet press is generally configured as a double-sided rotary tablet press, that simultaneously compresses and forms tablets on opposite sides of the rotary turret at separate compression stations. As shown in Fig. 5, the tablet press has a pair of three separate strain gauges 76 located at respective compression stations.

One of the three strain gauges monitors the compression force between rollers 42 and 44 (Fig. 2) to indicate the compression force which occurs at the time of tablet compression, i.e., final compression. A second strain gauge monitors the compression force between a pair of precompression rollers similar to and positioned upstream of rollers 42, 44. Precompression occurs prior to the final compression in order to slightly compact the powder to remove air from within the die cavity prior to compression. A third strain gauge monitors cam 46 (Fig. 2) at the time of "release" when the punch has moved to its upward position placing tablet 38 on the top of surface of the turret.

Each of the strain gauges 76 generates a control signal which is received by one of three peak detectors 78 that determine the peak of the control signal which represent the maximum strain on punches 34 at the associated compression, precompression or release stage. A plurality of peak detectors are utilized in the event that a strain reading of one punch occurs simultaneously with a strain reading of a following punch. The separate peak detectors hold the strain peak voltage reading until the control system is able to

5 read it. The analog signal from each peak detector is converted to a digital signal by an analog-to-digital converter 80. The digital signal is retrieved by a conventional microprocessor 84 which processes the signal for storage of information in random access memory (RAM) 88. Microprocessor 84 also controls reject gate 82 and a powder fill regulator 83 in accordance with processing of the retrieved strain gauge information.

10 Information is also provided to microprocessor 84 by a plurality of magnetic sensors, generally indicated by diagram block 86. The magnetic sensors monitor the movement of the turret relative to the associated compression station as well as monitor the proximity of the gauged tablet to the reject gate.

15 A master CPU 90 communicates with both RAMs 88 for retrieving the data processed by both microprocessors 84. Each microprocessor is responsible for mounting a single compression station on one side of the tablet press. Each microprocessor 84 stores in its respective RAM processed data based on information retrieved from its compression area. Master CPU 121 is able to retrieve from both RAMs the information necessary to communicate with the operator via a CRT 22.

20 Each microprocessor 84 looks at the individual punches of the tablet press for retrieving a plurality of data information to be stored in RAM 88 for each turret revolution. For example, for a tablet press which has 75 punches, microprocessor 84 will process data associated with each of the 75 punches and store the data in tabulated form in RAM 88.

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Master CPU 90 on the other hand, retrieves from RAM 88 tabulated information on a once per turret revolution basis.

5 Master CPU 90 may select and modify the program of microprocessor 84 for requesting the microprocessor to interrupt the master CPU at selected times, for example, before the processor changes peak compression values stored in RAM. The master CPU inserts into the code of the
10 microprocessor certain flags for communicating the time of interrupt. The program of the processor is stored in RAM which is accessible by the CPU.

In general terms, each reject gate 82 and powder fill regulator 83 is controlled by its
15 respective microprocessor 84. Also, each microprocessor stores data related to compression and release forces of its associated compression station. In the preferred embodiment, that data includes not only the compression forces at peak
20 compressions, but compression forces during "precompression" and during "release". The data stored in each RAM 88 is accessed by master CPU 90, allowing the master CPU to process the tabulated data and provide a variety of CRT displays of the
25 current activity of the rotary press.

Referring now to Fig. 6, microprocessor 84 controls the operation of peak detection circuitry, rejection gate circuitry and powder fill regulator circuitry via input/output ports 103. The data
30 retrieved by the microprocessor is processed and stored in RAM 88.

Microprocessor 84 addresses RAM 88 along an address bus 125 via an address buffer 127. RAM 88 responds to the address information appearing on
35 bus 125 for reading into or writing out of the

addressed location of RAM 88. The data appearing on a data bus 129 is read into or out from RAM 88. Microprocessor 84 transmits or receives data from data bus 129 via a data bus buffer 131.

5 Similarly, master CPU 90 addresses RAM 88 via an address bus buffer 133. Data received from or transmitted to RAM 88 by master CPU 90 is performed via a data bus buffer 135. Data bus buffer 135 and address bus buffer 133 are connected to respective
10 busses 129, 125.

 A pair of address decoders 137, 139 are utilized respectively by microprocessor 84 and master CPU 90 in order to enable RAM 88 for storage or retrieval of data. In order to share RAM 88, a
15 timing logic 141 supervises access to RAM 88 by either microprocessor 84 or master CPU 90.

 The clock phases of master CPU 90 and microprocessor 84 are out of phase by 180° . Thus, as the microprocessor 84 is setting up its address
20 information into address buffer 127 and decoder 137, the master CPU may access RAM 88. And when master CPU 90 is setting up its address information in buffers 133 and 139, microprocessor 84 may
25 access the RAM. Timing logic 141 performs arbitration between the data bus and the address bus to make sure there is no bus contention between the microprocessor 84 and CPU 90.

 As shown in Fig. 7, graph A represents the master clock of processor 84 and graph B represents the master clock of CPU 90. Both clocks are out of
30 phase by 180° . Graph C on the other hand, represents a pulse generated by timing logic 141 that places a dead band area at the time of switchover of the master clocks. This pulse is
35 used to prevent contention between the

microprocessor and CPU on the address and data buses.

Referring to Fig. 8, a strain gauge 201 is monitored by a peak detector circuit 209. Peak detector 209 is controllable by microprocessor 84 via a control logic 217 and a gain set circuit 219. The peak detector 209 generates a pair of output signals OUT and ADF.

Peak hold stage 209 monitors the strain gauge at the time of final compression of the tablet press. In the preferred embodiment of controller 12, three peak detector circuits like those of Fig. 8 are utilized. One peak detector monitors the strain gauge which represents the final compression of the tablet punches. A second peak detector monitors a strain gauge which represents the precompression of the tablet punches and a third peak hold circuit monitors a strain gauge which represents the release of the tablet press punches. Other like peak detector circuits may be utilized for other machine strains as will suggest itself.

Referring to Fig. 9, peak detector 209 is illustrated in more detail. A pair of input conductors 301, 303 are connected across a conventional strain gauge 304 for monitoring the voltage level impressed across the gauge in a conventional manner. A 1000 gain amplifier circuit 305, formed of an op amp 307, generates a voltage signal at a node 309 representative of the strain recorded by gauge 304. Amplifier circuit 305 includes a variable resistor RV1, interconnected to op amp 307 as shown.

A low pass filter 311 formed of a pair of operational amplifiers 313, 315, receive the strain

voltage signal from node 309 for generating a low pass filtered strain signal at node 317. Low pass filter 311 is conventional in construction including resistors R21-R24 and capacitors C19-C22, interconnected as shown.

The filtered strain signal appearing at node 317 is input to a gain set stage 319 which is variably controlled by gain set logic 219. Gain set stage 319 is formed from an operational amplifier 321, resistors R25, R26, variable resistors RV2, RV3 interconnected as shown. The output of op amp 321 generates an output ADF at node 323. The purpose of the gain set stage is to permit the microprocessor to select a higher gain for lower compression voltages in order to utilize the maximum range of the A-to-D converter.

Gain set logic 219 is formed of an analog switching device 325, resistor R105, and variable resistor RV15 interconnected as shown. Switching device 325 connects resistor R105 and variable resistor RV15 to conductor 327, in response to microprocessor command.

The ADF signal at node 323 passes to a conventional peak detector and hold circuit 329. Peak detector and hold circuit 329 includes a sample hold amplifier 331, op amp 333, a guard ring 335, (to prevent bleeding of holding capacitor C25) diodes D6-D8, resistors R27-R31, variable resistor RV4, and capacitors C23-C25, interconnected as shown. Circuit 329 detects the peak voltage of the ADF signal and generates an OUT signal which is a D.C. level of the peak voltage detected.

As shown in Fig. 10, the ADF1 compression waveform has a peak voltage or OUT1. The peak voltage of ADF1 occurs at time t4. A second strain

gauge waveform ADF2 is shown having a peak voltage OUT2 at time t2. The peak detector circuit 329 monitors the ADF curve and generates the OUT signal as the peak voltage.

5 Referring again to Fig. 9, control logic 217 generates a PR1 output between resistors R27, R28 and generates QRS1 output to input 8 of hold amplifier 331. These two signals PR1 and QRS1 serve to reset circuit 329 to zero in order to
10 prepare detector and hold circuit 329 for generating the next OUT1 signal of the following punch. Microprocessor 84 controls actuation of logic 217 for resetting the detector and hold circuit 329 at the appropriate time between peaks.

15 Control logic 217, which is activated by the microprocessor, is formed from an analog switch 337 and a monostable multivibrator 339, resistor R107 and capacitor C52 connected as shown. Logic 217 generates a PR signal and a QRS signal which resets
20 peak detector and hold circuit 329. Logic 217 generates PR and QRS in response to command from microprocessor 84.

Referring to Fig. 11, a multiplexer 401 monitors the OUT and ADF signals of up to four peak
25 detector circuits 209. Multiplexer 401 is controlled by microprocessor 84 for transmitting a selected ADF or OUT signal to a sample and hold circuit 403. A 12-bit A-to-D converter 405 converts the signal stored in sample and hold
30 circuit 403 to a digital output onto microprocessor bus 406 and determines whether the signal of sample and hold circuit 403 is below zero volts. If the signal goes below zero volts, an error signal is generated.

35 A-to-D converter 405 is switchable by

microprocessor 84 through a conventional bipolar converter 407 for checking whether the signal stored in sample and hold circuit 403 is negative. Microprossecor 84 commands converter 405 to list
5 for a negative voltage that indication is placed on data bus 406. If the microprocessor senses that a negative signal has been generated, it reports to the operator via CRT 21, indicating an error signal.

10 Referring to Fig. 12, a punch proximity sensor 801 is positioned in a fixed relationship with the tablet press for monitoring rotating punches on the press. Sensor 801 generates an electrical pulse in accordance with the movement of each punch past
15 sensor 801. A mark or other sensible indicator may be placed on the turret at each punch position for sensing by sensor 801. Alternatively, the bolt or screw holds each punch into the turret may be sensed.

20 Successive pulses which are generated by sensor 801 are fed along a conductor 803 via an optical isolation circuit 804. An exclusive OR gate 806 passes the signal of conductor 803 to a voltage controlled oscillator/detector circuit 805
25 via input conductor 813. Oscillator/detector 805 generates an oscillating output along a conductor 807 connected to a counter 809. The counter increments in response to the oscillating signal on conductor 807. The most significant bit output of
30 counter 809 is transmitted back to oscillator/detector 805 via a conductor 811 for phase comparison with the oscillating signal input from conductor 813. Oscillator/detector 805 changes the frequency of the output signal on
35 conductor 807 in order to place the two oscillating

input signals 811, 813 into phase.

Thus, each bit in the count of counter 809 represents an incremental time slot between the movement of successive punches past the punch proximity sensor 801. The count output of counter 809 is monitored by microprocessor 84 via buffer 815.

Exclusive OR gate 806 serves as a programmable inverter. Microprocessor 84 inverts the signal appearing on conductor 803 via conductor 802. This permits a change in the leading edge of the oscillating signal for conformance with oscillator detector circuit 805.

In order to initialize itself, processor 84 monitors the ADF signal via converter 405 (Fig. 11). As the ADF voltage increases to the peak and then begins to decrease, the processor determines the peak point. At that time the processor retrieves the count stored in buffer 815 (Fig. 12) as an indication of the time slot during which compression (or precompression or release) takes place. Thus, the microprocessor determines the angular position of the turret within which the peak values occur during the compression, precompression and release modes. Microprocessor 84 stores in its memory those time slots for use in retrieval of peak values from peak detector 209 (Fig. 8).

Microprocessor 84 retrieves the peak data from A-to-D converter 405 (Fig. 11) by transmitting the stored peak count to a comparator 817 (Fig. 12) for comparison with the repeating counts in counter 809. When the comparison is made, comparator 817 generates an output signal "M" for indicating time

of compression. Microprocessor 84 thus transmits to comparator 817 the particular time slot (count) in which it wishes the signal M to be generated. The signal M is generated for indicating that the multiplexer 401 should pass the associated analog signal to the sample and hold 403 and the A-to-D converter 405 should perform the conversion. The processor commands A-to-D converter to perform the conversion.

The M signal is used to interrupt microprocessor 84. Upon being interrupted, the microprocessor looks at the time slot count stored in comparator 817 for determining the appropriate routine to execute.

Referring to Fig. 10, the subsequent occurring peak (at t_{20}) will occur, for example, 16 time slots after the peak (at t_4) of the previous punch. In order to detect the subsequent peak, the peak detector 209 needs to be reset prior to time t_{20} . The microprocessor thus will reset peak hold t_{12} in preparation for detecting the peak of the next compression waveform.

Similarly, if the peak of the precompression waveform (ADF2) occurs at a time t_2 (Fig. 10), the microprocessor monitors the counter 809 (Fig. 12) via comparator 817 for indicating the time occurrence of the peak of the precompression curve (ADF 2) for passing the precompression signal to sample and hold circuit 403 and commanding conversion by the A-to-D converter. The microprocessor then resets the peak hold circuit at the appropriate time via its associated control logic 217. Thus, a number of peak detector circuits can be controlled using a single magnetic sensor monitoring the punches moving into the

compression area.

Referring to Fig. 12, a turret sensor 701 is positioned in a fixed relationship with the tablet press for monitoring a mark or other indication on the rotating turret. Sensor 701 generates a voltage pulse signal along a conductor 703 indicating that a single turret revolution has occurred. This indication is fed to microprocessor 84. An optical isolation circuit 705 may be utilized between sensor 701 and conductor 703 as will suggest itself.

Referring again to Fig. 4, a reject gate controller logic 501 is directly controllable by microprocessor 84 for actuation of gate 503 to deflect the tablet into discard bin 58. Solenoid valves 70, 72 are electrically actuated by controller 501 for operation of gate 503.

Microprocessor 84 is programmed with information as to the relative position of the reject gate from the release compression stage. Thus, the microprocessor will know the number of time slots, i.e., the angular position of the turret at which to actuate the reject gate. Alternatively, a magnetic sensor may be used which can be monitored by the microprocessor for actuation of the reject gate a predetermined time after sensing by the magnetic sensor.

Reject gate controller logic 501 (Fig. 4) is actuated at a certain time slot, i.e., angular position of the turret, in order to open pressure valve 66 to pass air out of nozzle 54. A predetermined number of time slots later, reject gate controller logic 501 is again actuated by the microprocessor in order to close the pressure operated valve 66.

5 As understood, the operator adjusts the tablet
press as well as the powder fill regulator in order
to obtain the tablet of the desired physical
characteristic that he or she seeks. After he has
achieved the desired tablet in terms of size,
weight, hardness, etc., he actuates the press
controls 26 (Fig. 5) switching the system from its
manual mode to its automatic mode and the control
10 system takes over to continue producing such a
tablet. The microprocessor 84 averages the
compression forces of all the punches for one
revolution. That average compression force
information is stored in RAM 88 as a compression
set point and is utilizable in order to continue to
15 make the selected tablet when the operator places
the system in the automatic mode. In the automatic
mode the processor controls the compression with
respect to the particular compression set point
stored in RAM 88 by adjusting the powder fill
20 regulator 83.

Microprocessor 84 stores in tabular form in
RAM 88 the peak values for each punch for the
precompression, compression and release stages.
With that information, the microprocessor 84
25 generates an average compression force and compares
that with the set point compression force in
memory. If the comparison indicates too great of a
deviation, the powder fill regulator 83 is adjusted
to bring the average compression back towards the
30 set point compression value.

Microprocessor 84 also compares each separate
compression peak with respect to an upper and lower
limit from the set point compression value in order
to determine whether a particularly formed tablet
35 should be rejected at reject gate 82.

Microprocessor 84 decides whether to reject the tablet by comparing the compression force associated with the tablet with respect to a preset range of compression values.

5 If the particular punch that made the tablet is longer than the other punches, the particular compression force associated with that particular punch will always be higher than the other punches. This is true even though the amount of powder used to make the tablet, and thus the tablet weight, is the same.

10 In order to compensate for length of punches, the compression forces for a particular punch are averaged over a number of turret revolutions. That average is utilized to set or to establish a deviation from that average in order to decide whether to eject the tablet made by that punch. Thus, the length of the punches is automatically compensated by the computer.

15 As a digital compression value is retrieved from the A-to-D converter, that value is normalized in accordance with its particular associated punch to determine whether to eject the tablet. The compression force averages of all of the punches are averaged to come up with a single compression average. Then the separate compression average of a particular punch is compared with the overall average. The difference in the average compression for a particular punch with respect to the overall punches average is used as a compensation value to bring the compression force of that particular punch to a normalized value. The difference in the average is subtracted from the output of the A-to-D converter in order to normalize the compression force for that particular punch. Thus,

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as each punch's compression force is normalized, the normalized compression force is compared with a single deviation value. This serves to eliminate punch length variations on their compression values and provide the operator with a single set of deviation limits. With a single deviation limit the operator is able to tell how well the flow of powder into the die pocket is occurring.

In order to adjust the compression forces, particular punches can be interchanged with one another on the tablet press. The computer is able to determine from the highest average compression force (as to particular punches) and the lowest average compression force (as to particular punches) which punches should be switched in order to bring the punches more towards the average compression force. One of the punch pairs (of the two punches at a punch location) with the highest compression average should be switched with one of the punch pairs with the lowest compression average. This is to obtain a uniform tablet hardness, if tablet hardness is a consideration in the product, as for example where the product is to have certain time release characteristics. The weight of the tablet, of course, does not change, only its tablet hardness.

Referring now to Fig. 13, a display performed by the master CPU is illustrated. The CPU generates at a location 911 a total count of the number of good (non-rejected) tablets produced by the rotary press. This output is continuously incremented during the operation of the press. Likewise, a display 81 indicates the number of rejects, that is the number of tablets rejected from either side of the double press mechanisms.

(location 89) can be displayed, showing what compressive forces in the punches will result in operation of the reject gate mechanism 82.

5 A display of press performance (location 91) is shown indicating a statistical analysis of the compression force information at frequent intervals. The CPU 90 calculates the standard deviation using information of the average force, maximum force, and minimum force. The co-efficient
10 of variation can then be calculated using the standard deviation. The co-efficient of variation is displayed as a percent subtracted from 100 and gives the operator a real time measurement of the variation from interval to interval of the press
15 operation. This can be calculated once every revolution. This is shown visually in box 91.

Fig. 14 illustrates a histogram 93 displaying the number of tablets produced at their various compressive forces. Force is plotted along the
20 X-axis and the number of tablets are displayed in vertical bar graph form, allowing a visual indication of all of the compressive forces. Also, actual data can be generated next to the histogram as shown at 94.

25 A third display is illustrated in Fig. 15. The compressive force for each punch for a particular side of the doublesided press can be illustrated, with the punch number illustrated on the X axis and peak force amplitude illustrated on
30 the Y axis 97. The plot shows the range of compressive force amplitudes 98 for each punch, as well as shows the punch peak force 99 of the last revolution. The information displayed in Fig. 15 allows proper adjustment of individual punches so
35 as to minimize the total variation from the lowest

As will suggest itself, the total count of tablets does not include the tablets sampled or discarded at press start-up or shut-down. That is, in the manual mode no counting occurs until the system is switched to automatic mode.

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Alternatively to display 911, a buzzer or alarm may be generated which signals the operator to empty the good tablet container bucket when it reaches its capacity. The number of tablets could be set via keyboard 24. Instead of actuation of an alarm, the alarm signal can be used to actuate a solenoid to change buckets or to perform other actions in accordance with the desire of the operator.

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The master CPU also displays information regarding the compressive forces on the various punches. A compression scale 83 indicating in hundredths of pounds is displayed vertically. To the left and right of compression scale 83, compression indications are provided respectively for the left and right half of the double rotary press. An historic range of average compression forces is illustrated by a bar scale 85 displayed in black with the averaged compression forces of the last revolution displayed in white (86). Alternatively, only the averaged compression forces of the last revolution can be displayed as shown at 88.

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The display can show the compression to which the press is set (set point) and the bar scale will show variations above and below that desired force level. In Fig. 13, the left array of punches is set at 3,000 pounds and the right array at 3,000 pounds, as indicated by the indicia "SET" 87. Likewise, the upper and lower limits of rejection

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5 punch peak compressive force to the highest punch peak compressive force. Thus, the total variation of all tablets produced will be reduced. For example, as shown in Fig. 15, one of the punch pairs of punch 10 may be replaced with one of the punch pairs of punch 15.

WHAT IS CLAIMED IS:

1. An apparatus for measuring and displaying information regarding tablets produced in a rotary tablet press having a mechanism for rejecting defective tablets and a plurality of tablet dies each with an associated tablet punch set, comprising, in combination:

means for producing data indicative of tablet compression at least one tablet die location;

data processing and mechanism control means, connected to the first means, for processing the tablet compression indicative data and controlling operation of the defective tablet rejection mechanism;

data storage means, connected to the processing and controlling means, for addressably recording at least a portion of the information processed by the data processing and mechanism controlling means;

second means for processing the compression indicative data connected to the data storage means and adapted to process information stored in the storage means concurrent with the action of the data processing and mechanism control means; and

means for introducing and withdrawing information from the second means for processing the compression indicative data.

2. An apparatus as claimed in claim 1, wherein the rotary press includes a second mechanism adapted to regulate powder fill in the dies, and the data processing and mechanism control means also controls operation of the powder fill regulating mechanism while providing powder fill information to the data storage means.

3. An apparatus as claimed in claim 1, wherein the means for producing compression data, the data processing and mechanism control means, and the data storage means together comprise a
5 press control unit, and the apparatus further comprises a plurality of press control units, each connected by its data storage means to the second means for processing the compression indicative data.

10 4. A method of controlling and monitoring operation of a rotary tablet press mechanism having a plurality of tablet press stations, each station having a die with a corresponding pair of opposed punches, comprising the steps of:

15 producing data indicative of the compressive force between punches at each punch station as tablets are formed;

processing the compressive force data in an information processing device;

20 controlling operation of mechanisms that are peripheral to the punch stations concurrently with the processing of data in the information processing device; and

25 displaying data processed by the information processing device to allow monitoring, concurrently with the operation of the tablet press mechanism, of both tablet compressive force for each press station and statistical abstracts of the tablet compressive force for each press station over time.

30 5. A method as claimed in claim 4, further comprising the step of displaying information indicative of the operation of the mechanisms

peripheral to the punch stations concurrent with the display of processed tablet compressive force data.

5 6. A method as claimed in claim 4, wherein the tablet press stations are mounted on a rotary turret and the tablet press mechanism includes sensors that provide information indicative of turret and tablet movement, further comprising the steps of:

10 processing turret and tablet movement information concurrently with the processing of the compressive force data; and

15 controlling operation of the peripheral mechanisms in response to both the compressive force information and turret and tablet movement information.

20 7. Instrumentation for controlling and monitoring a rotary tablet press mechanism having a plurality of tablet press stations, each station having a die and a pair of opposed punches to compress powder into a tablet, comprising, in combination:

25 two or more strain gauges adapted to monitor compressive forces within tablets during formation by determining strain in the tablet punches forming the tablets, with one strain gauge adapted to produce information indicative of final compression of the tablet punch, and a second strain gauge adapted to produce information indicative of either,
30 precompression of the tablet punches or release compression of the tablet;

means connected to the strain gauges for converting the compression information into a

convenient form; and

means for controlling operation of tablet press peripheral devices in response to the converted strain gauge information.

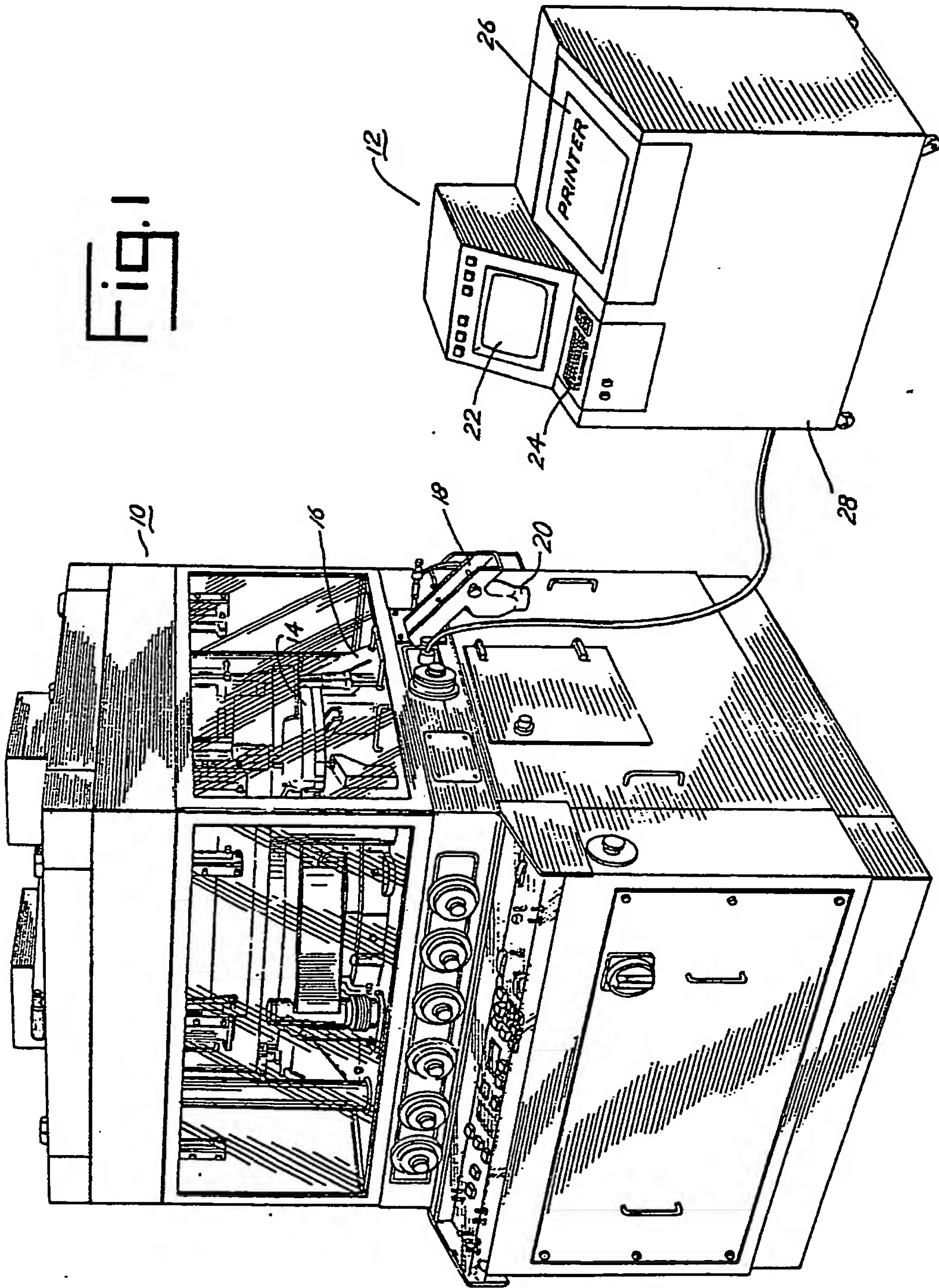
5 8. Instrumentation as claimed in claim 7, wherein the means for controlling operation of the peripheral devices also processes information, the instrumentation further comprising:

10 means for storing information connected to the means for controlling operation of the peripheral devices, such that compression information from the strain gauges is addressably stored;

 means for additional processing of information connected to the means for storing information; and

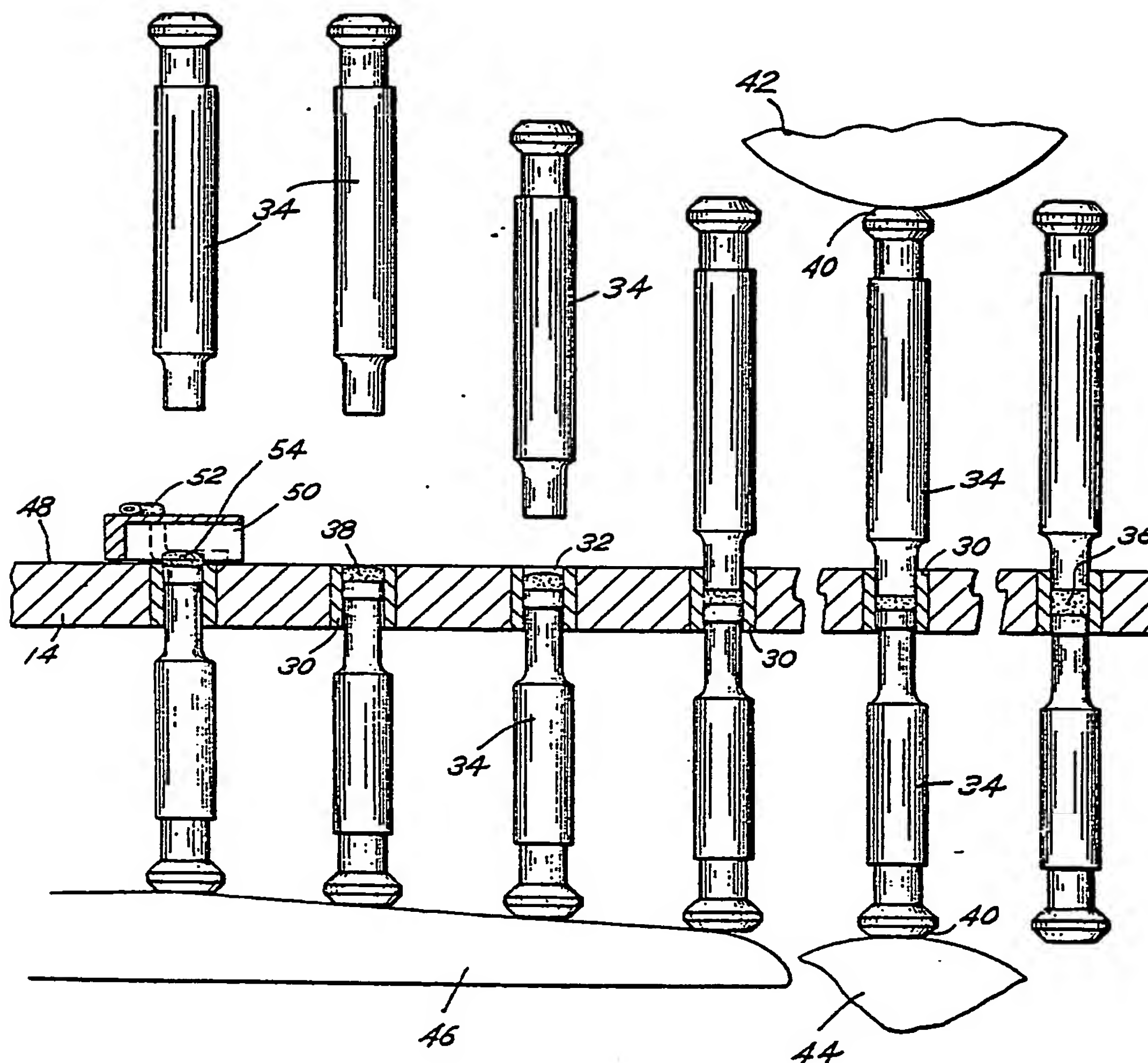
15 means for displaying the additionally processed information.

Fig. 1



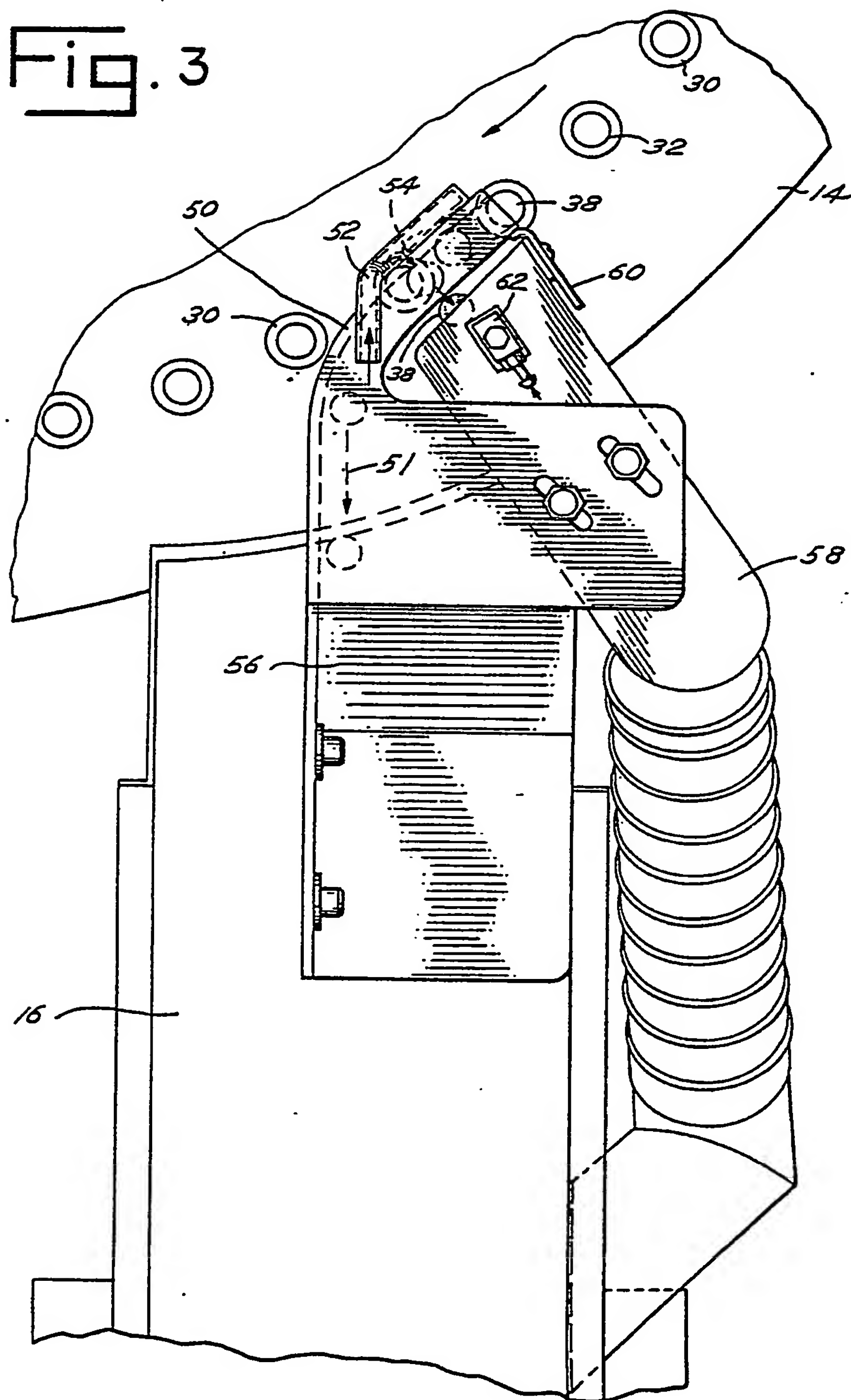
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Fig. 2



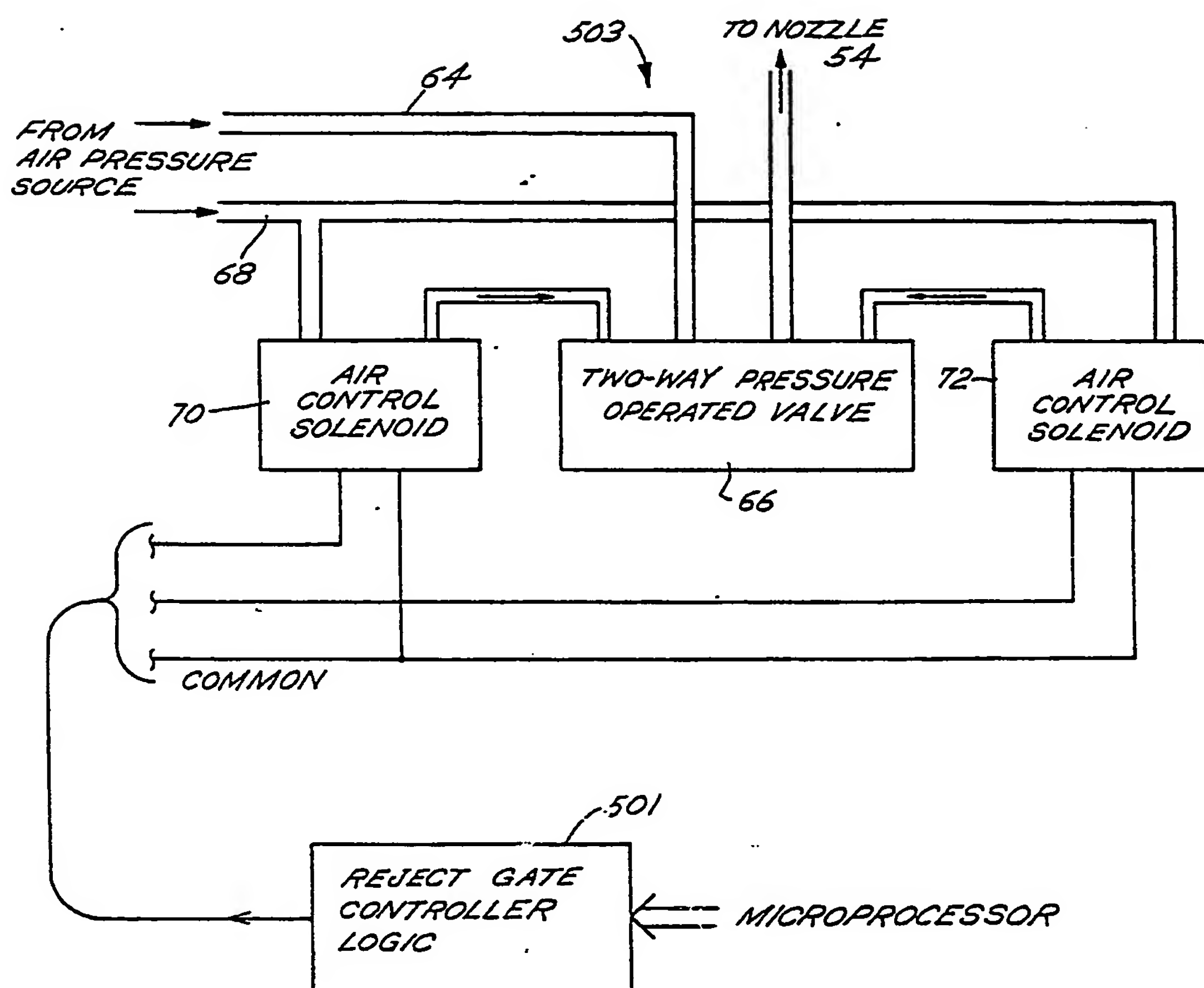
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Fig. 3



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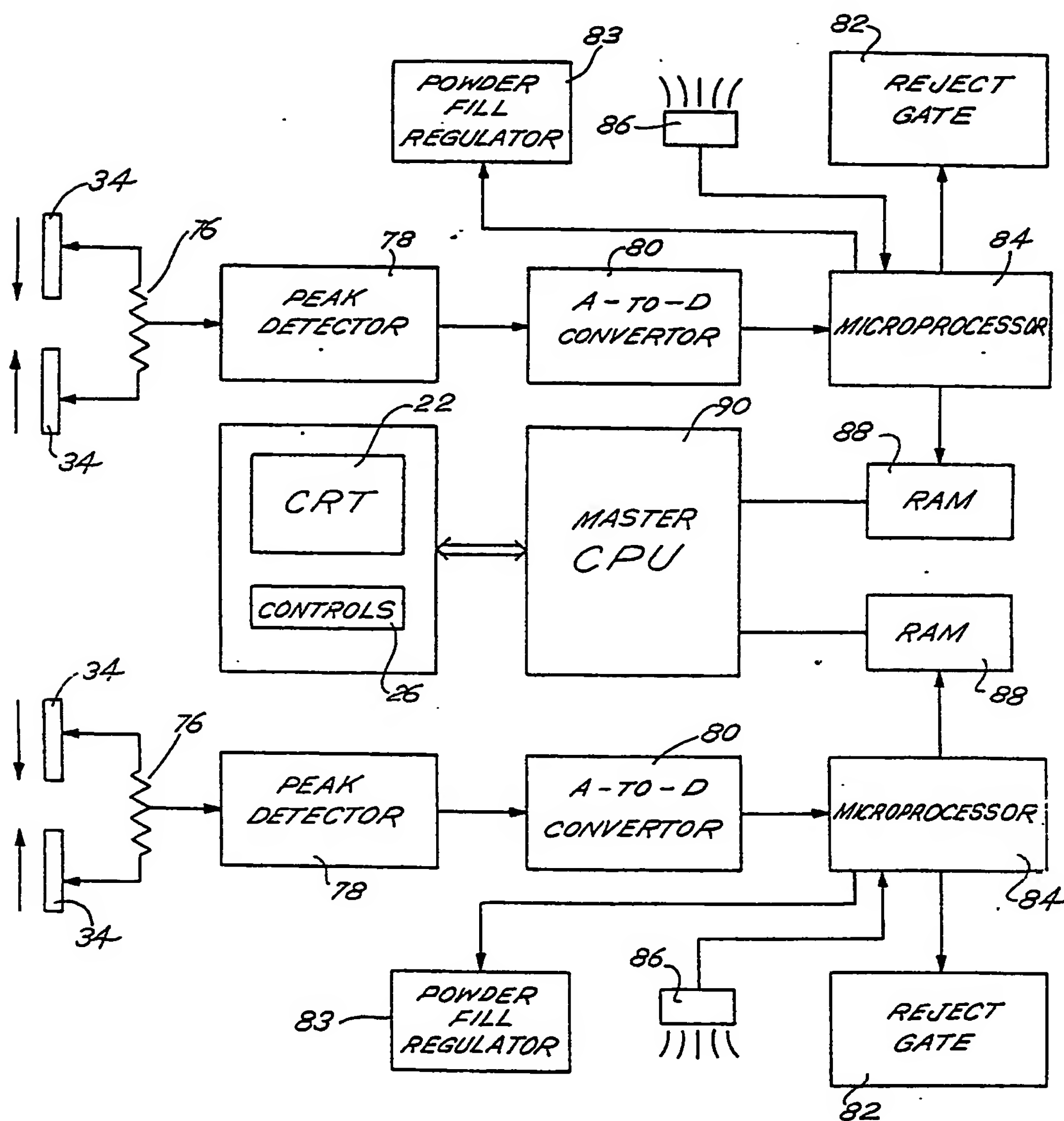
Fig. 4



C. SUBSTITUTE SHEET

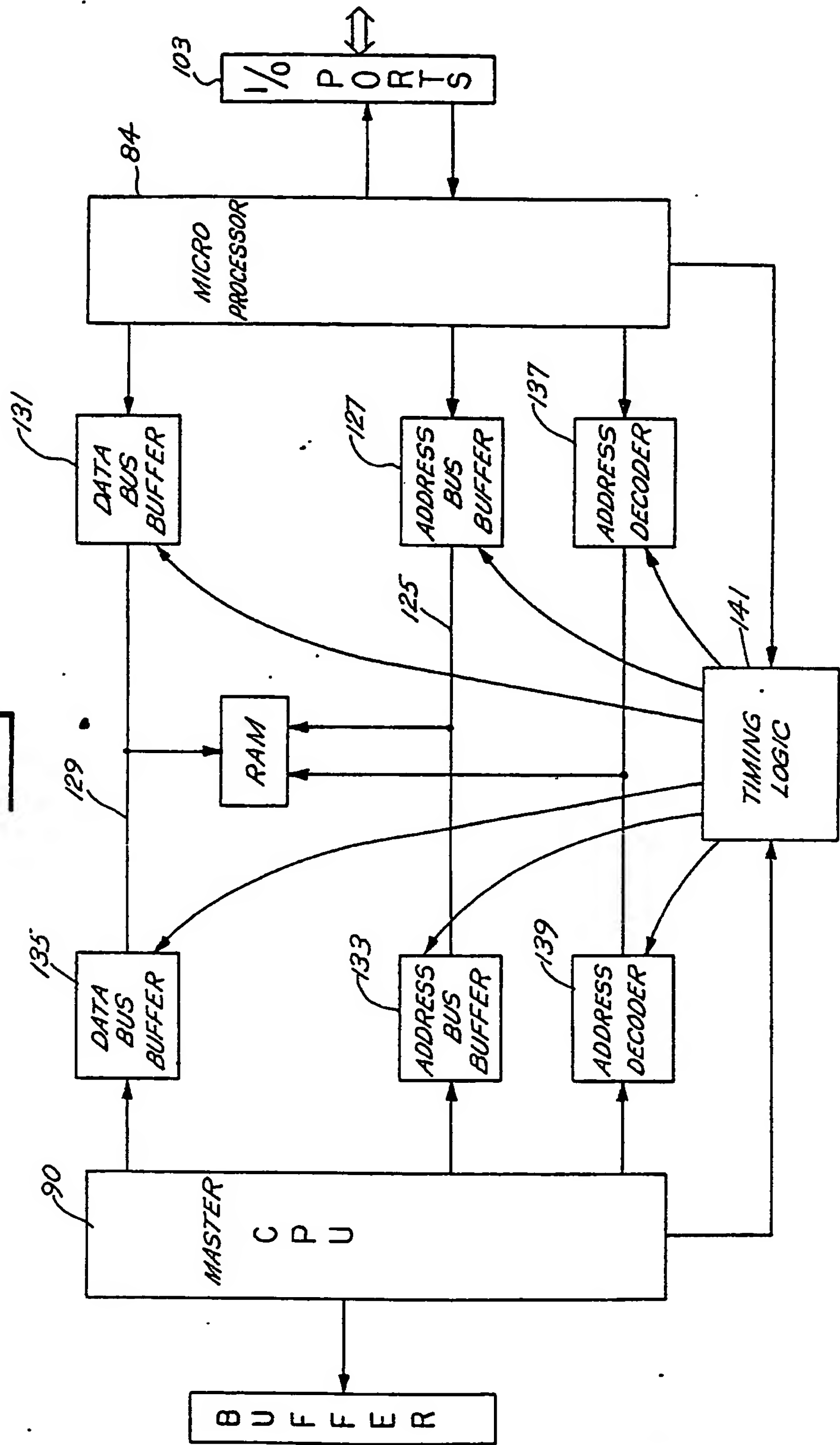
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Fig. 5



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Fig. 6



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Fig. 7

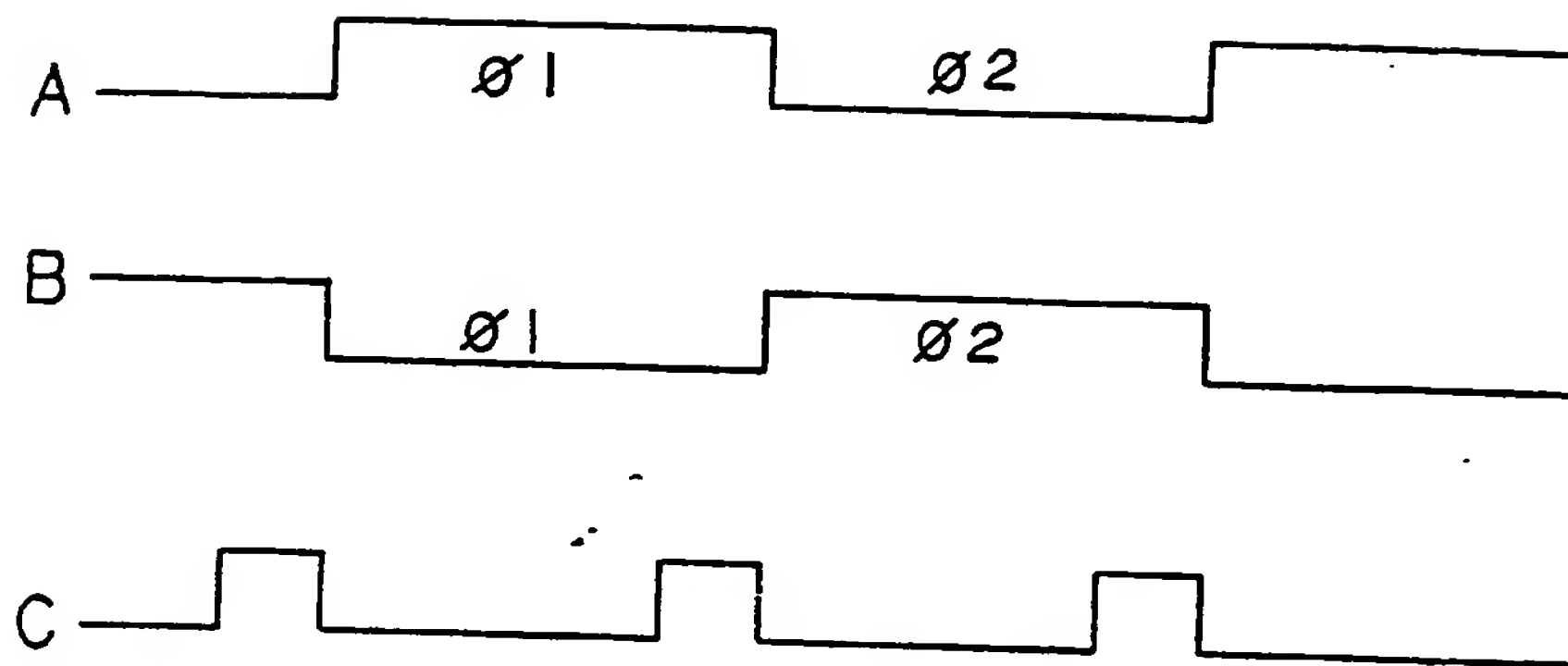
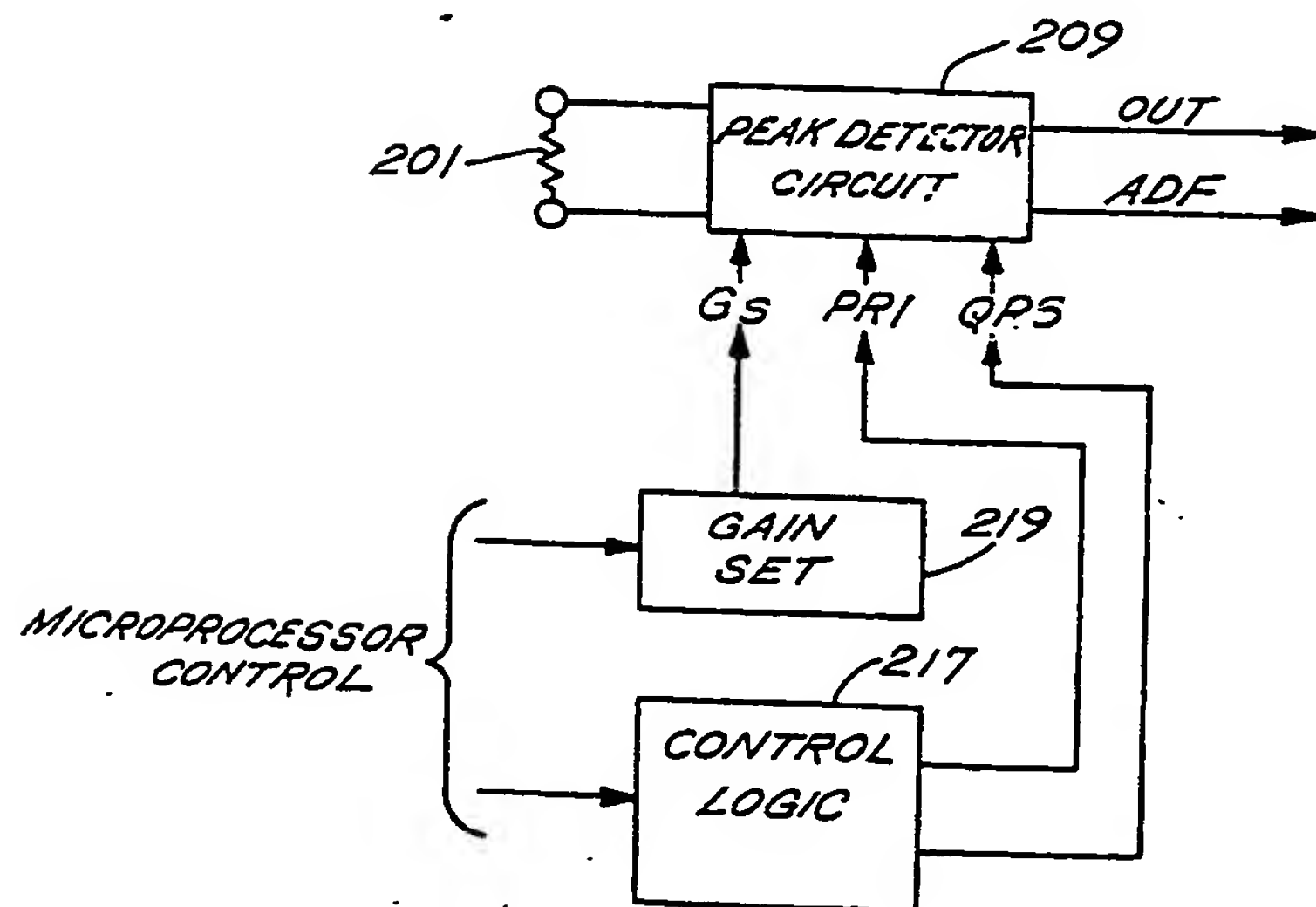


Fig. 8



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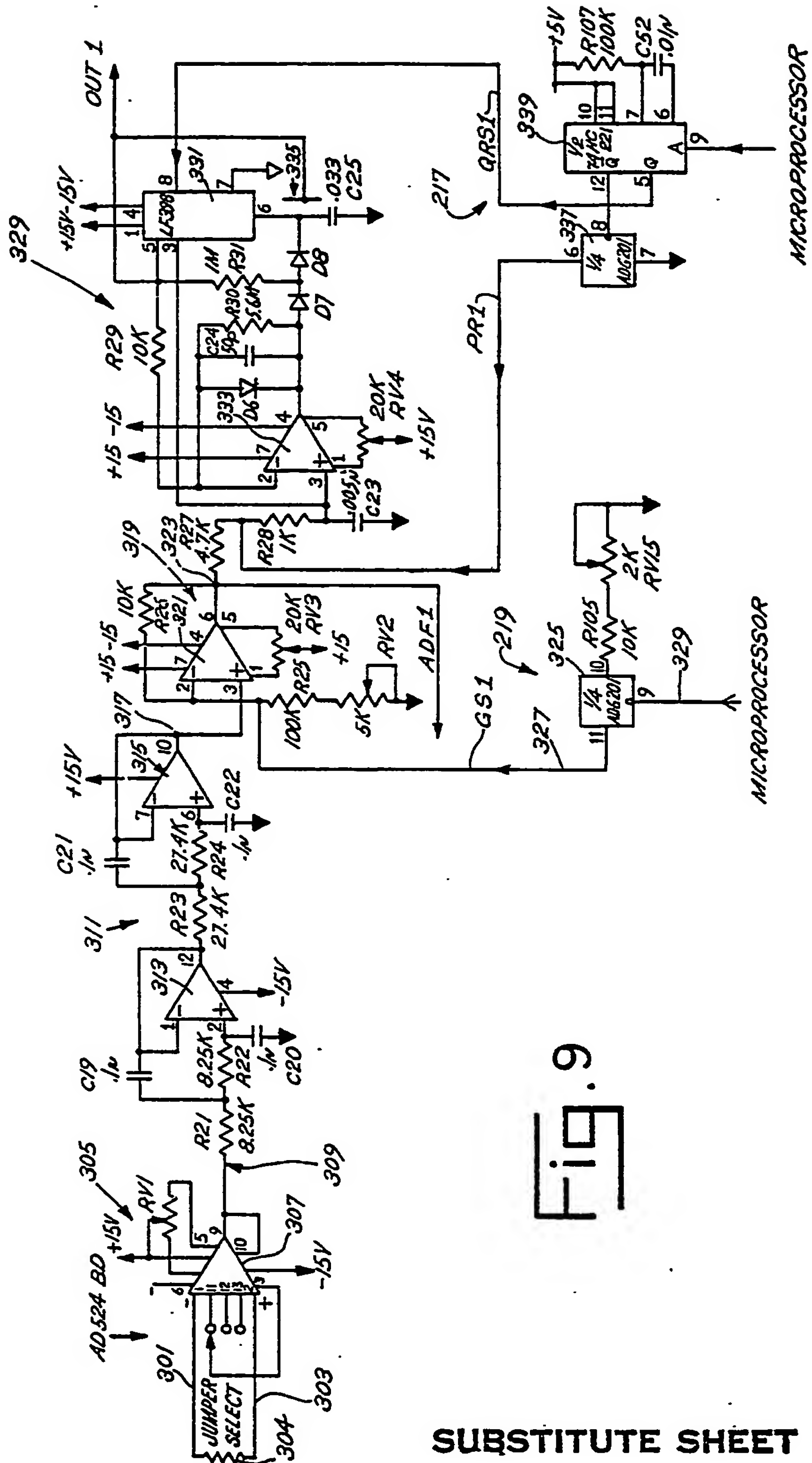


Fig. 10

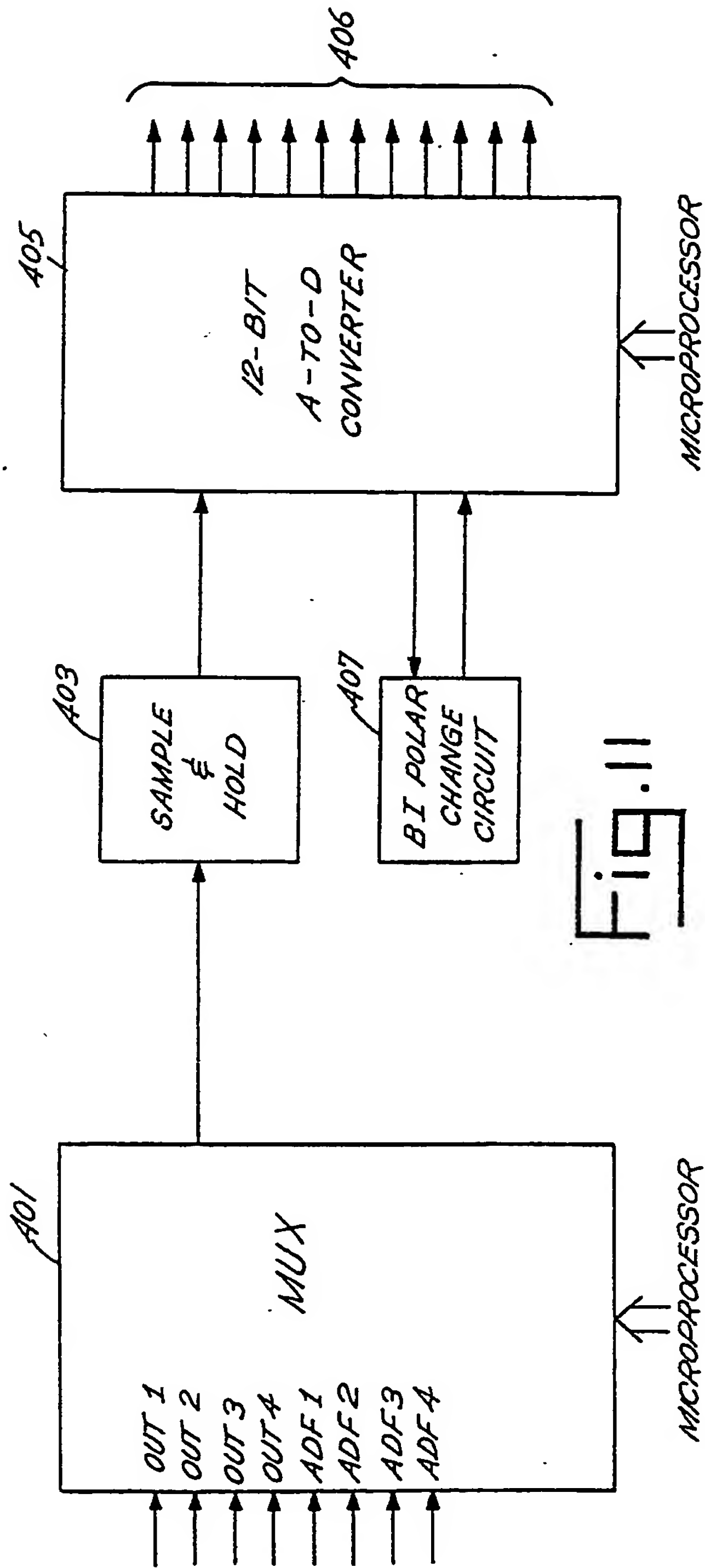
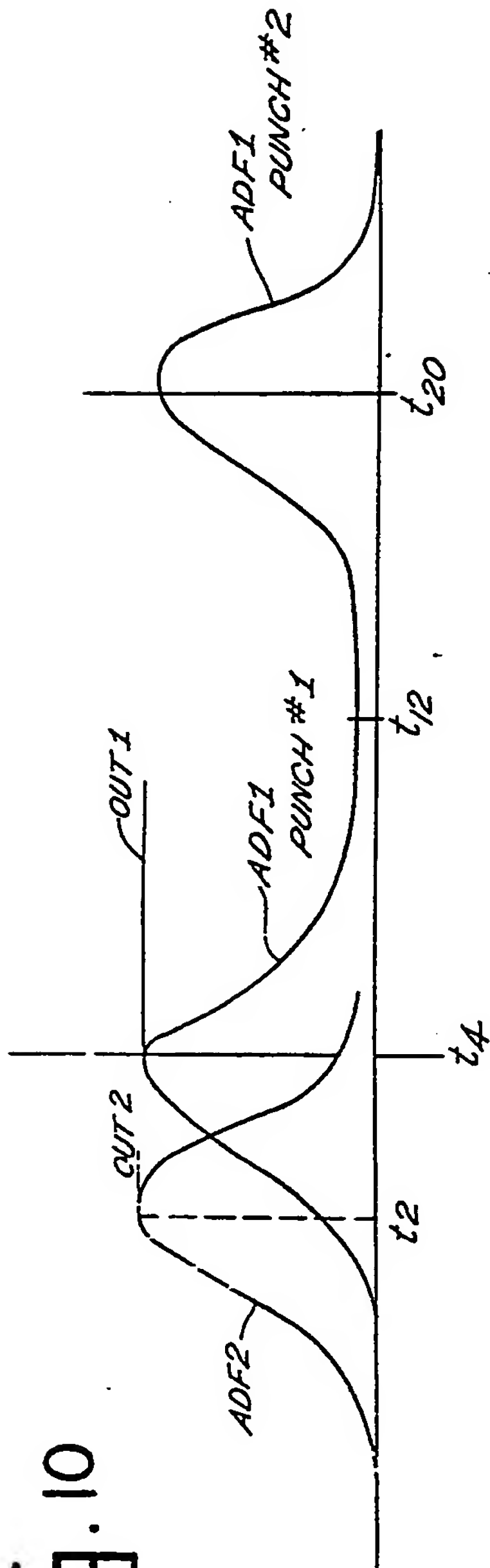
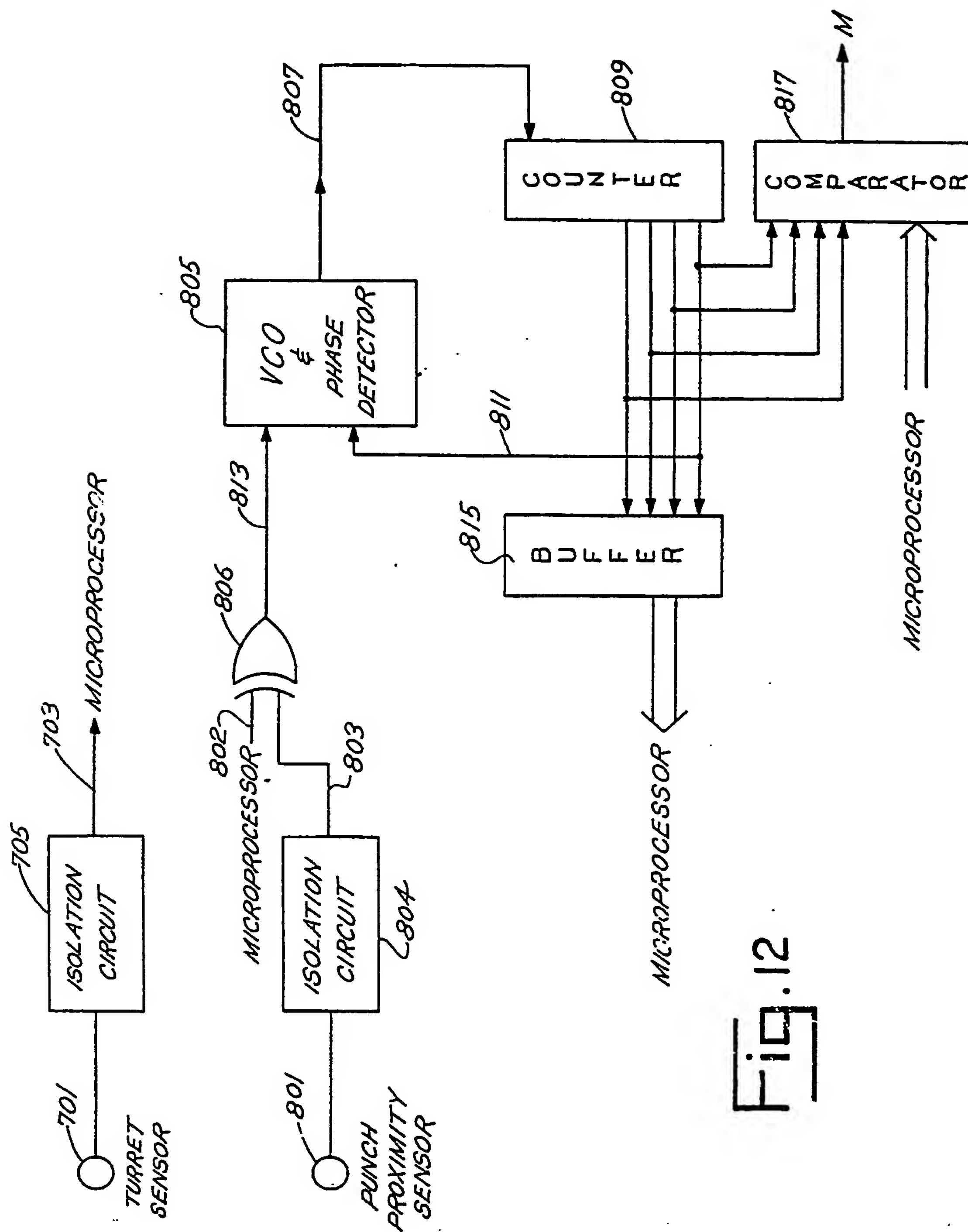


Fig. 11



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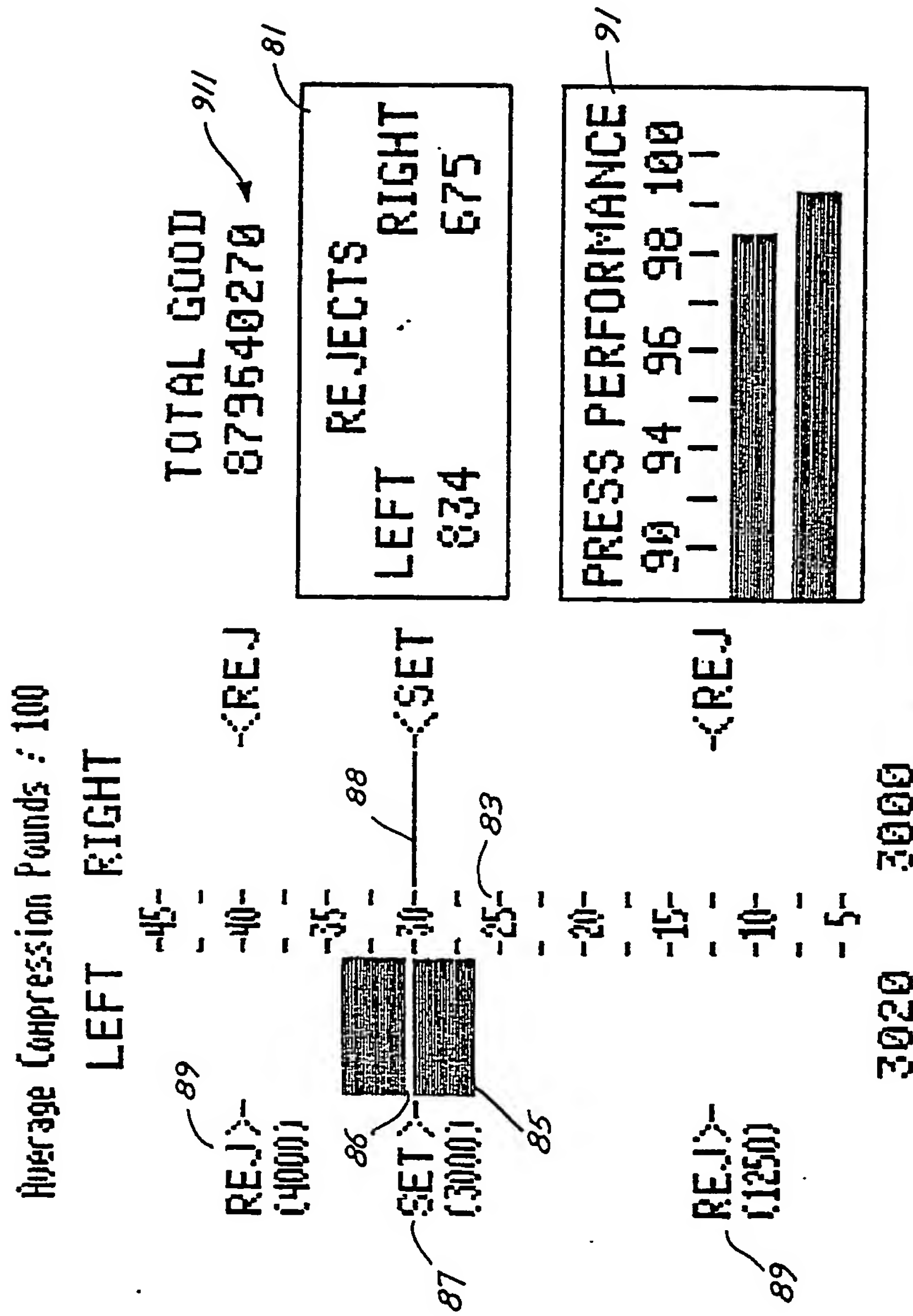


Fig. 13

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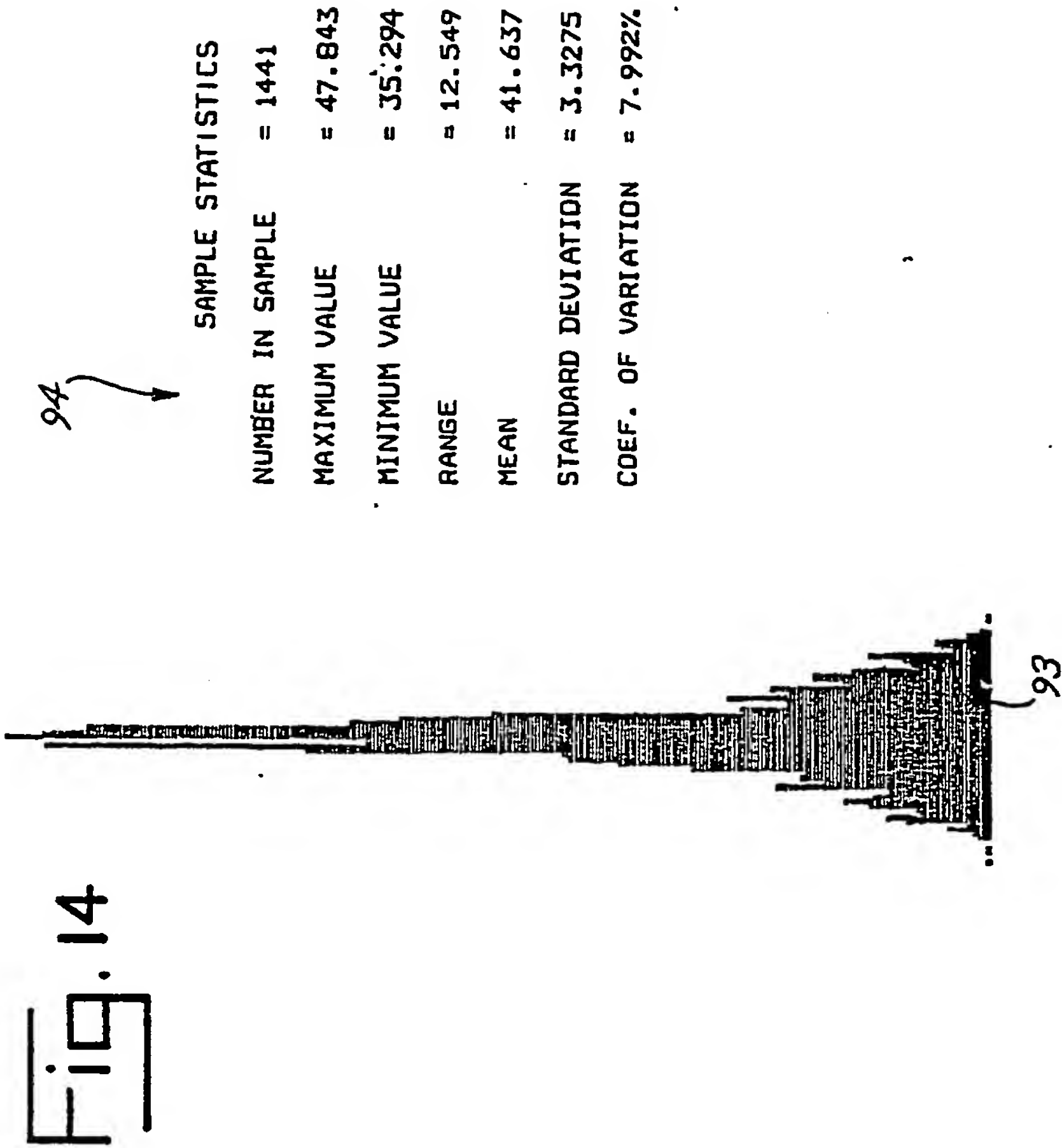
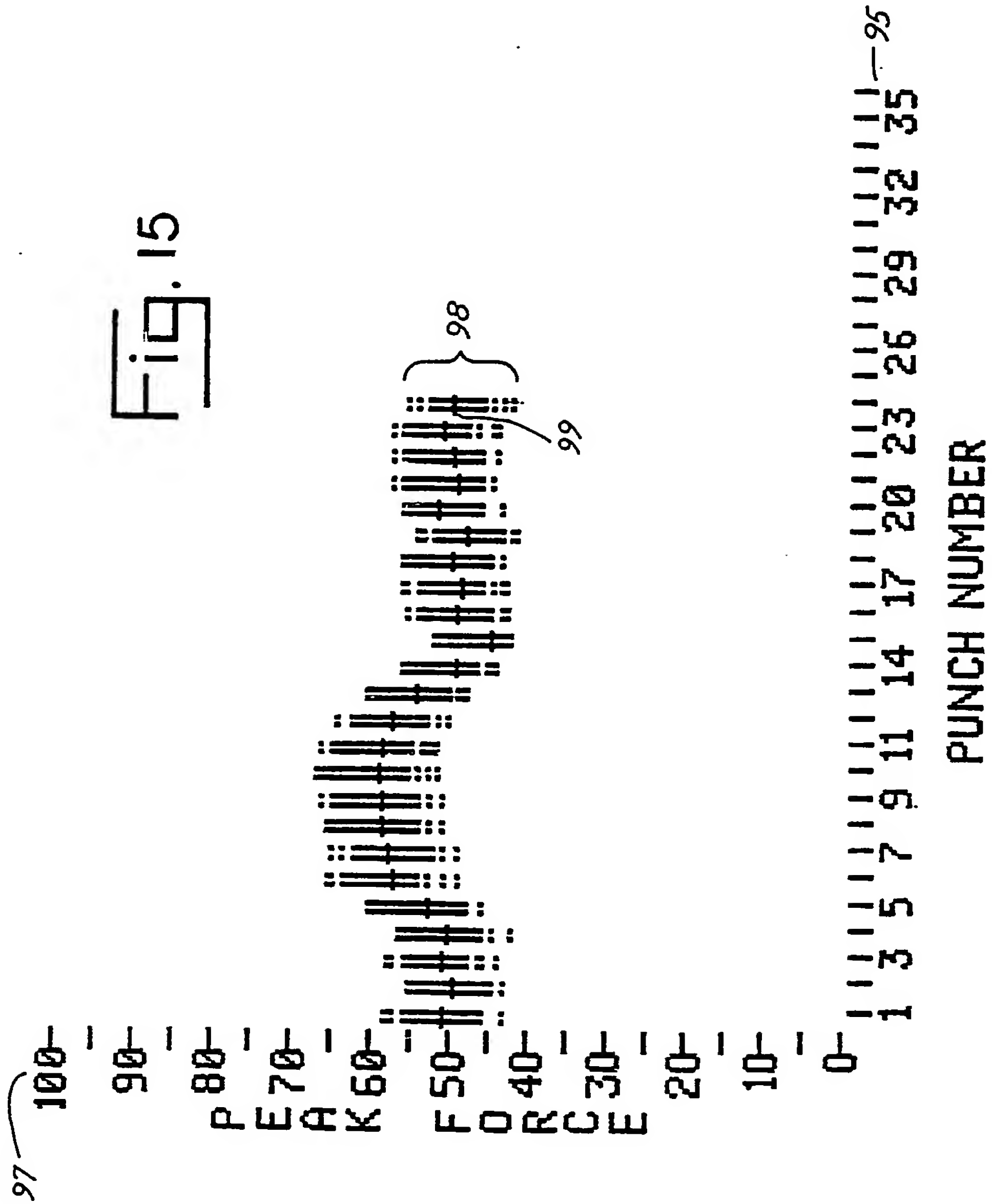


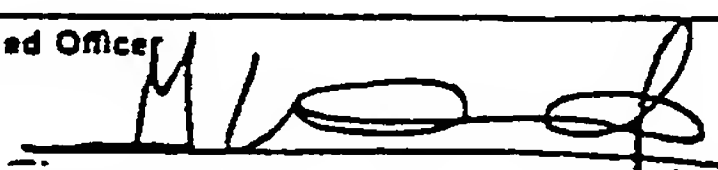
Fig. 15



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INTERNATIONAL SEARCH REPORT

International Application No PCT/US 86/00580

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) *		
According to International Patent Classification (IPC) or to both National Classification and IPC		
IPC ⁴ : B 30 B 11/00		
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
IPC ⁴	A 16 J B 30 B G 06 F	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched *		
III. DOCUMENTS CONSIDERED TO BE RELEVANT *		
Category *	Citation of Document, ¹¹ with Indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
Y	US, A, 4099239 (J.J. WILLIAMS) 4 July 1978, see the whole document	1, 4, 6-8 3, 5
A	--	
Y	US, A, 4109309 (R. JOHNSTONE) 22 August 1978, see column 1; column 2, lines 1-49; figure 1	1, 4, 6-8
A	--	
A	Manufacturing Chemist & Aerosol News, volume 50, April 1979 P. Bathe: "Recent developments in tableting technology, pages 33, 38, 40, see page 38; page 40, paragraph "Instru- mentation and ejection force"	1, 4, 6, 7
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A	--	
A	US, A, 3255716 (E.L. KNOECHEL) 14 June 1966, see the whole document (cited in the application)	./.
<p>* Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the International filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
26th June 1986.	17 JUL 1986	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	M. VAN MOL 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO.

PCT/US 86/00580 (SA 12684)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 04/07/86

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For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82

INTERNATIONAL APPLICATION NO.

PCT/US 86/00580 (SA 12684)

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For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82